The Salmonid Population Viability Project

Seth Wenger, University of Georgia

Motivation:

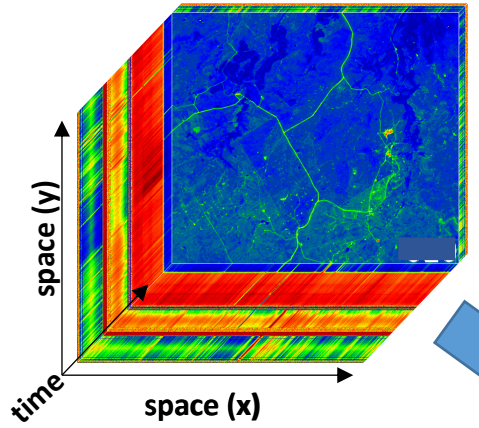
How do we allocate scarce resources
for species that occur in
multiple isolated populations?

NASA remote sensing

enables

Spatio-temporal geodata

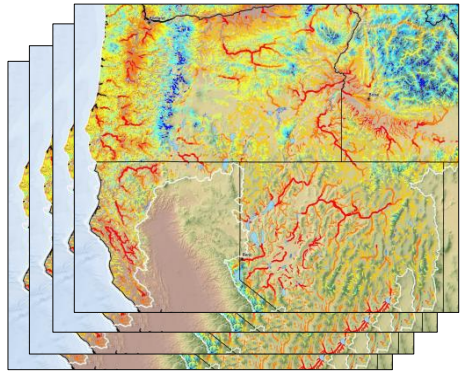
(long-term & large-scale)



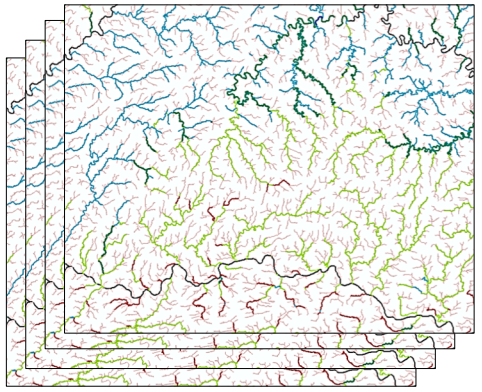
essential for

Stream habitat models

Temperature (NorWeST)



Hydrology (NLDAS/VIC)

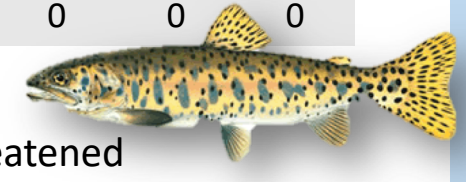


State & federal imperiled population monitoring

produces

Spatio-temporal biodata

Site	2010	2011	2012	2013
A	2	0		
B	10	25	12	1
C			5	
D	0	0	0	0



Federally-threatened
Lahontan cutthroat trout

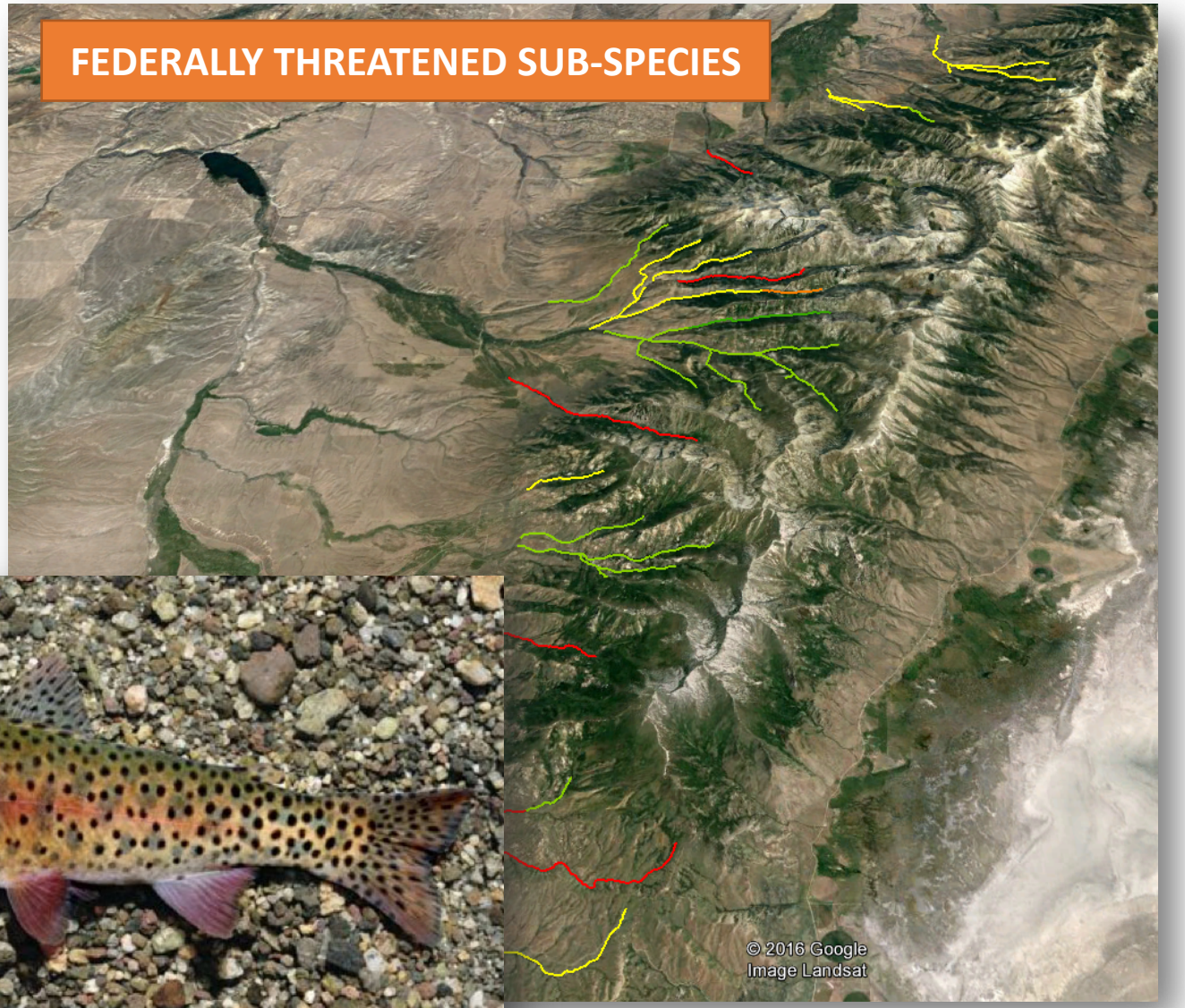
Salmonid Population Viability Project

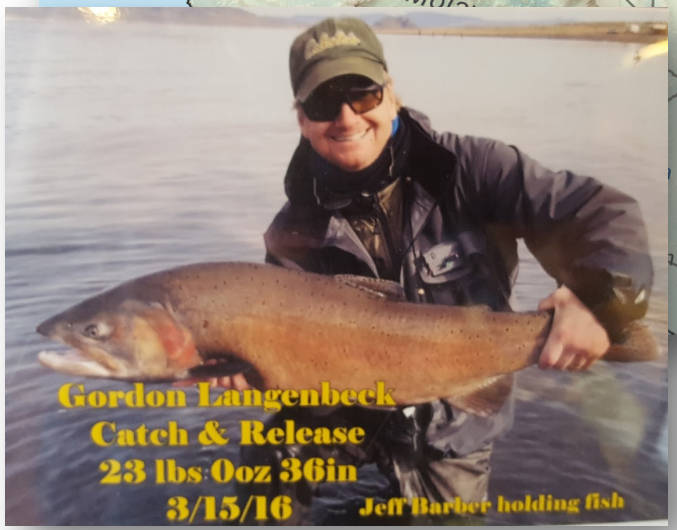
Remote sensing enables borrowing from data rich populations for inferences in data poor populations

- **New population viability modeling framework** combines remote sensing with field surveys to estimate extinction risks for populations range-wide (including those without biological data)
- **Web tool** for managers to assess extinction risks under future climate and management scenarios http://trout.shinyapps.io/lahontan
- **Decision making support** using all available data
- **Added value** to existing biological datasets

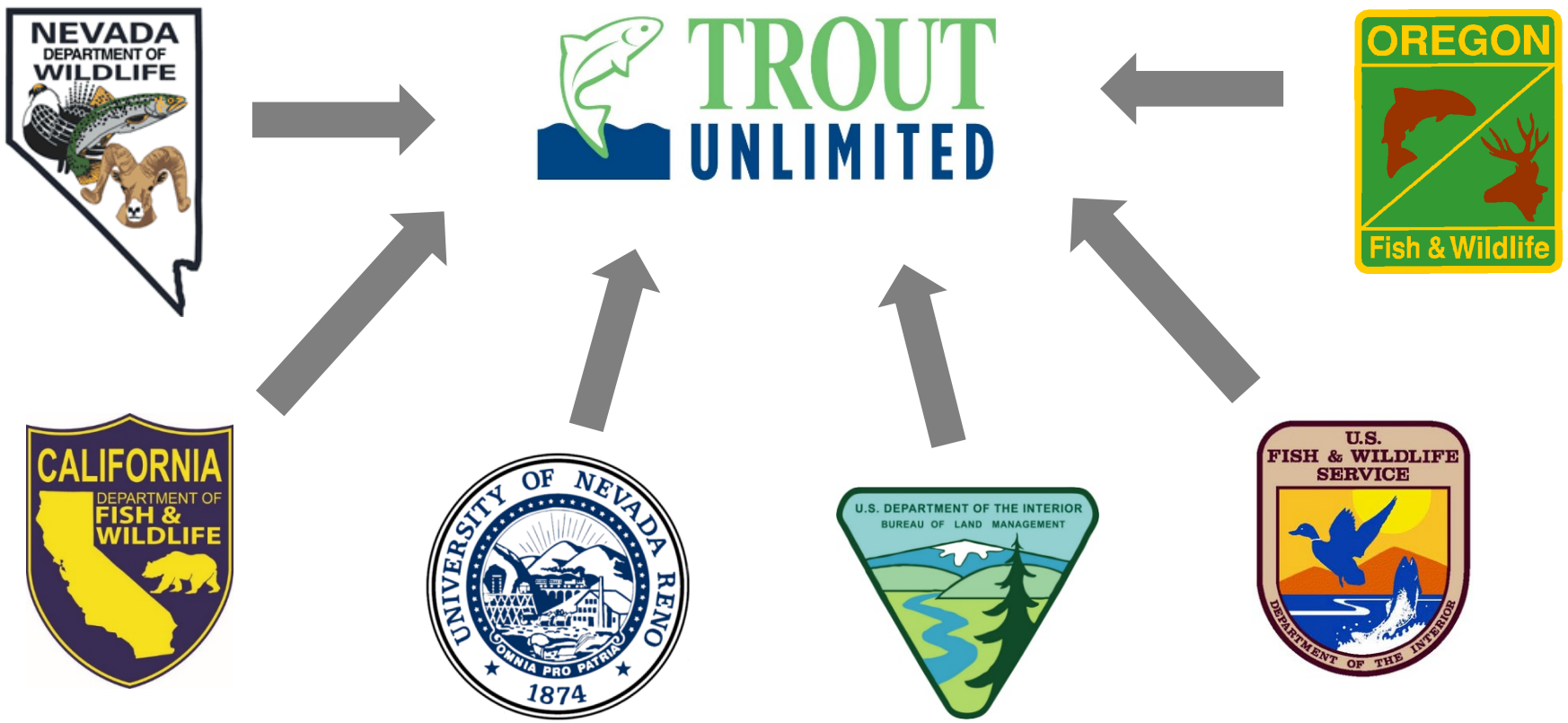
Lahontan Cutthroat Trout

(*Oncorhynchus clarkii henshawi*)

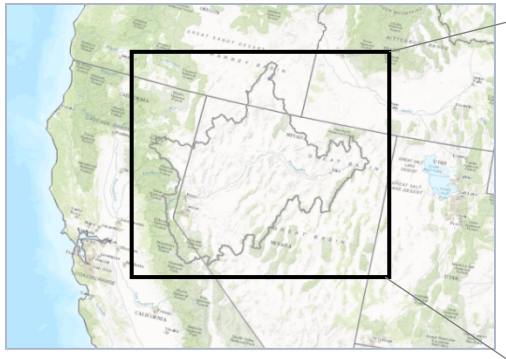




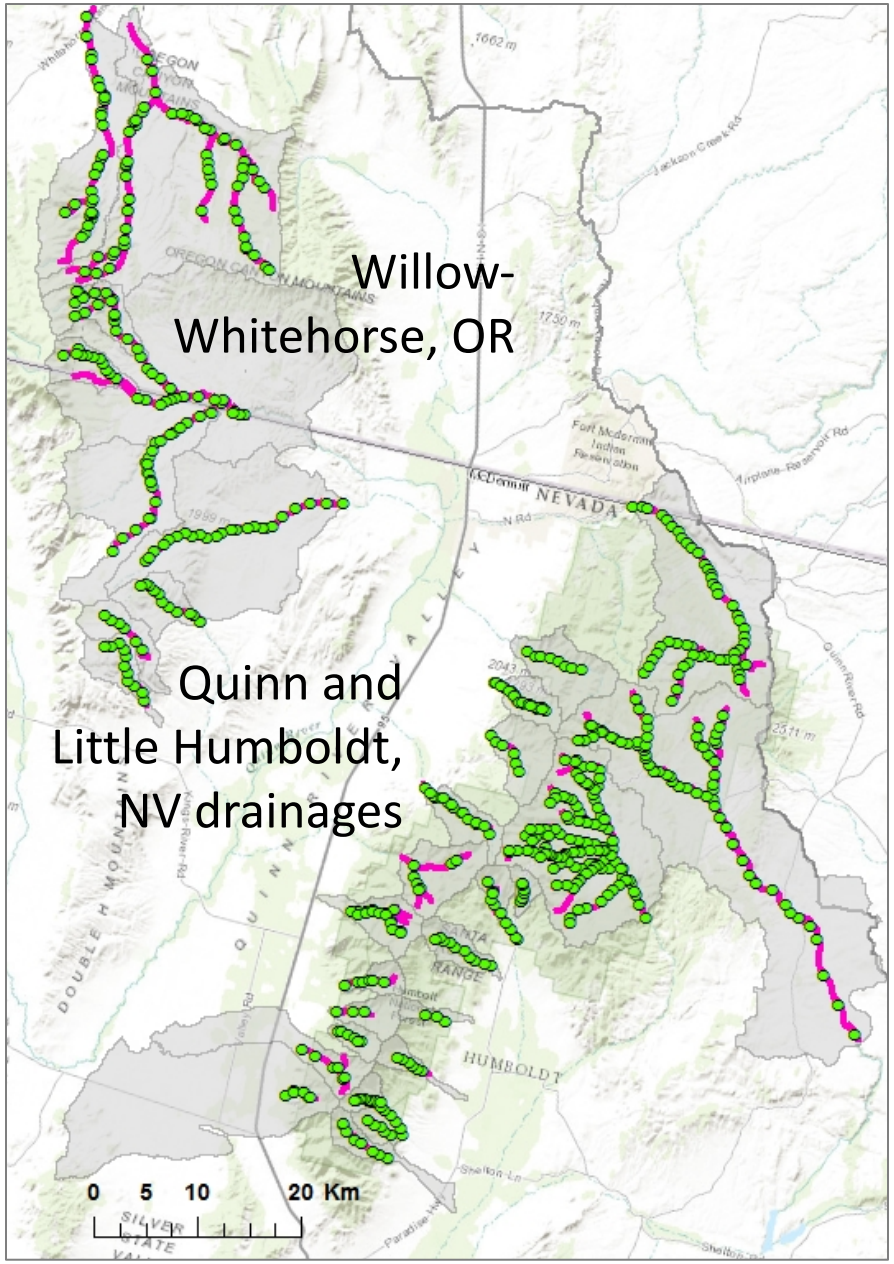
Lahontan Cutthroat Trout Database

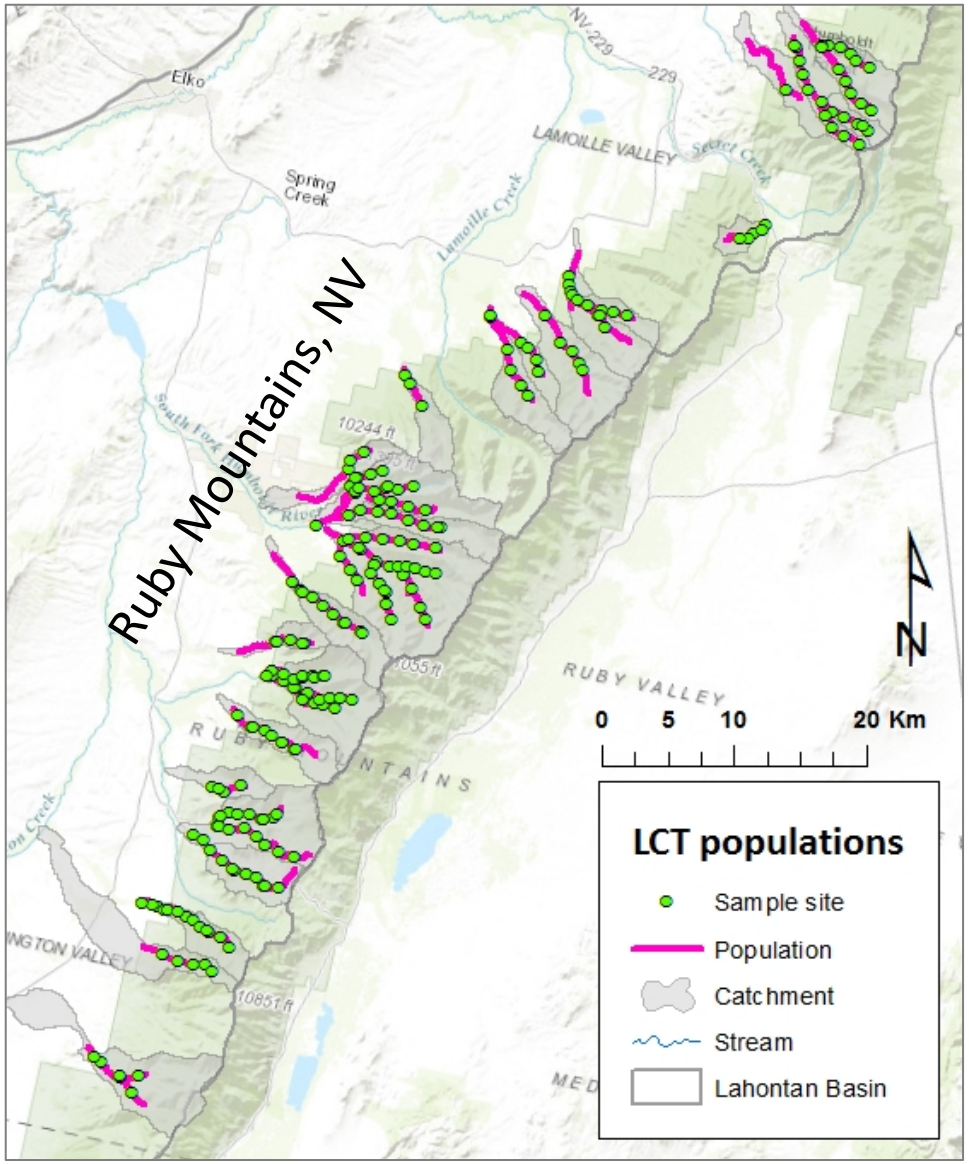


What's in the Lahontan cutthroat trout database…



- 1985 – 2015 (30 years)
- 232 populations
  - 155 populations with data
  - 69 FWS conservation pops
- 1,806 sampling sites
- 3,980 sampling events
- 196 miles of electrofishing
- 23,499 individual TROUT
- 15,265 individual LCT (Age 1+)


Willow-
Whitehorse, OR
Quinn and
Little Humboldt,
NV drainages
NEVADA
HUMBOLDT
0 5 10 20 Km

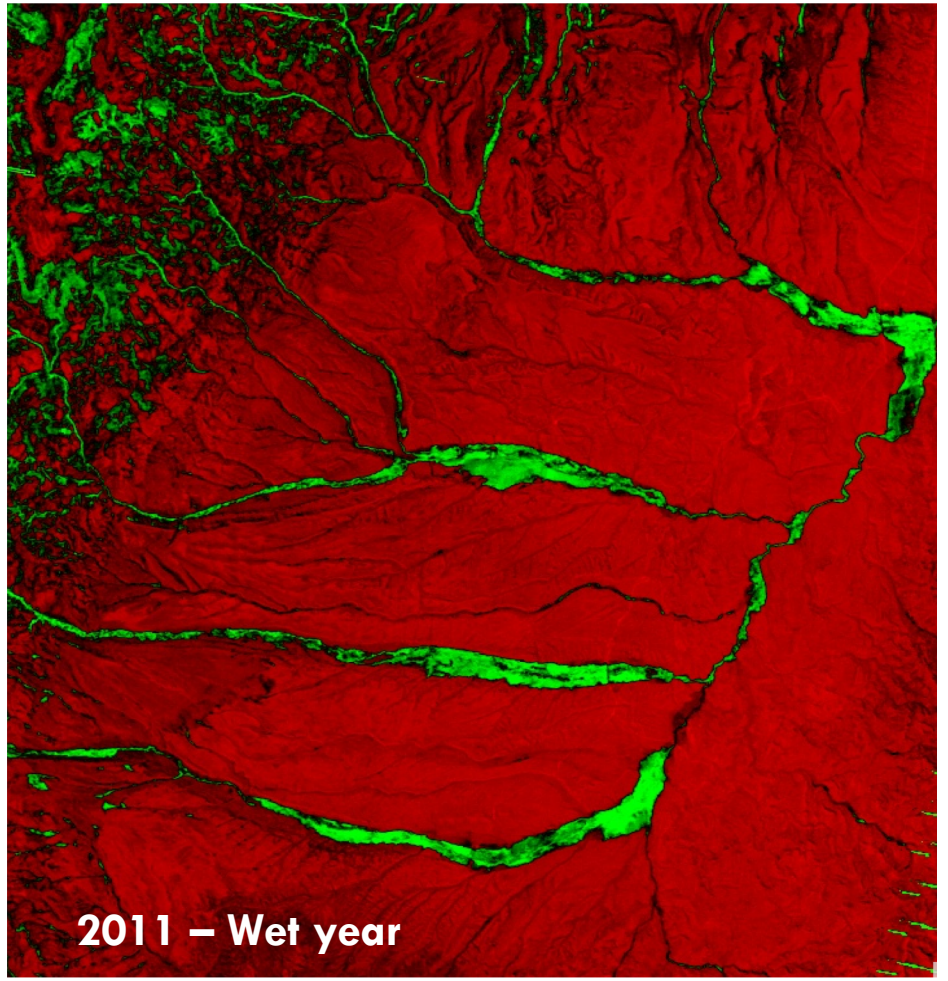

Ruby Mountains, NV
Elko
Spring
Creek
LAMOILLE VALLEY
RUBY VALLEY
0 5 10 20 Km
LCT populations
Sample site
Population
Catchment
Stream
Lahontan Basin

Environmental covariates => Demographics

Normalized Difference Vegetation Index (NDVI)

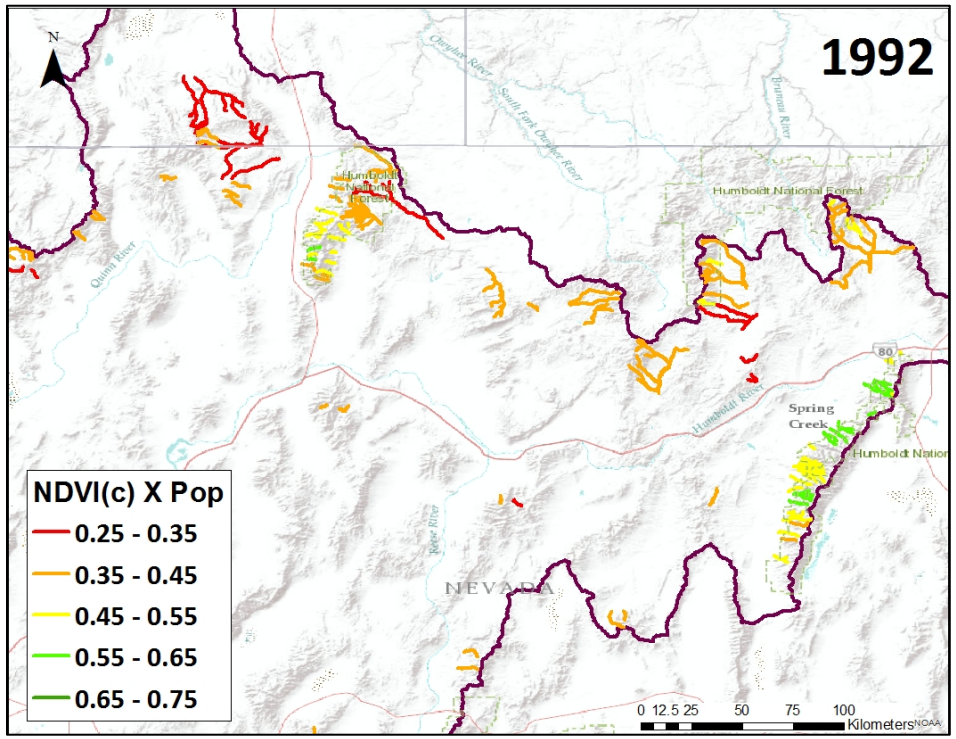
Landsat, 1985-present

Active photosynthesis and vegetation

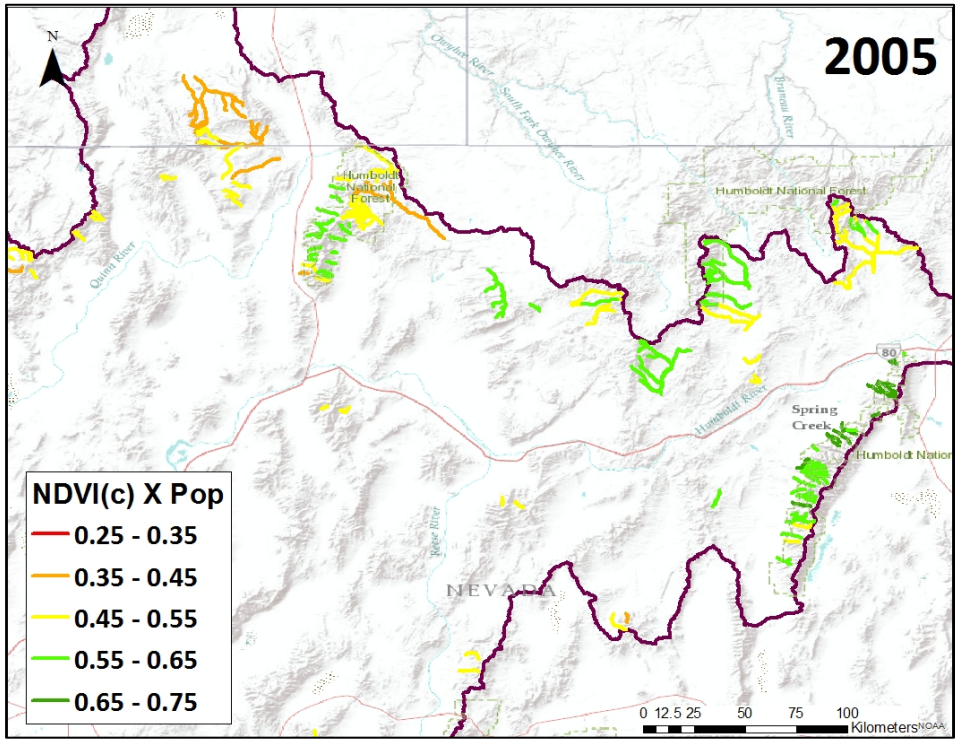


NDVI: Population x Year

Dry year



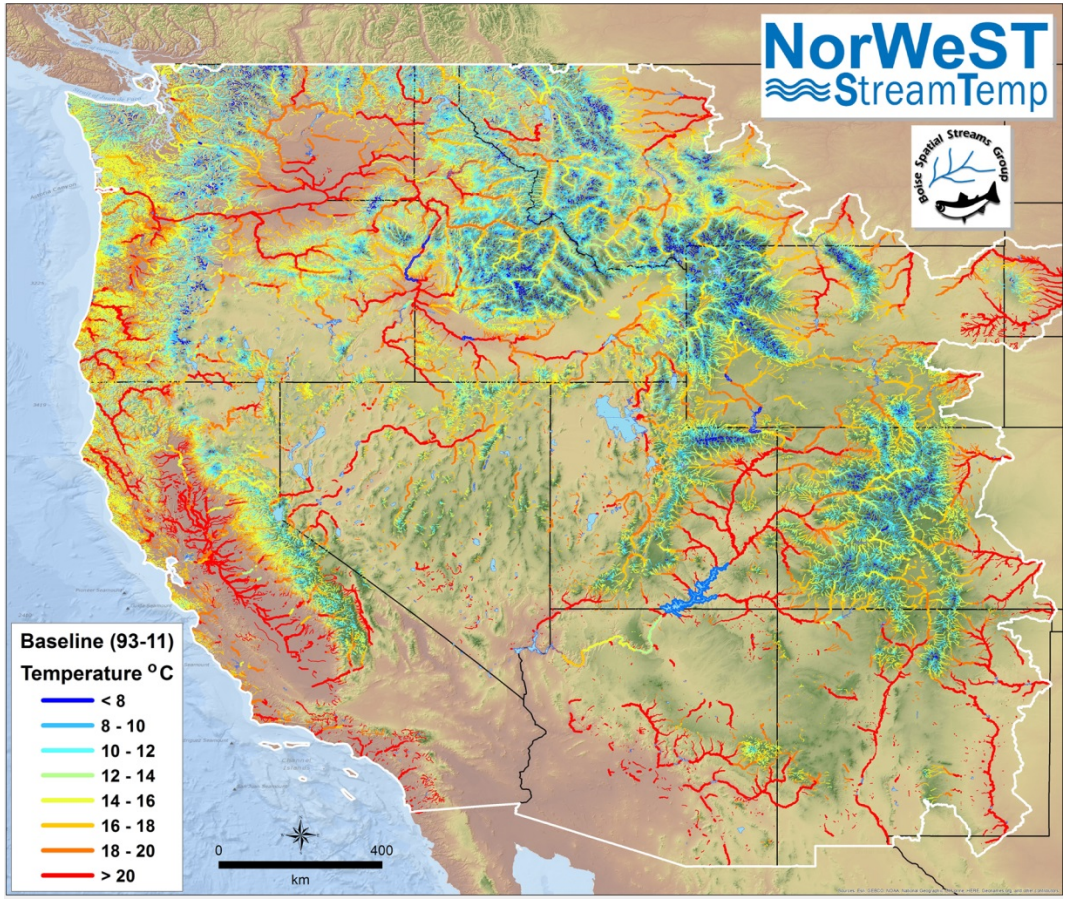
Wet year



river basin CENTER

Stream Temperature

- Annual estimates of mean August stream temperature for every 1km stream segment
- Derived from weather stations, GIS layers, and remote sensing (AVHRR, Landsat, MODIS, NAIP)



river basin CENTER

Stream hydrology

Annual high flow (NLDAS)

JOURNAL OF GEOPHYSICAL RESEARCH
Atmospheres
AN AGU JOURNAL

Climate and Dynamics

The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system

Kenneth E. Mitchell, Dag Lohmann, Paul R. Houser, Eric F. Wood, John C. Schaake, Alan Robock, Brian A. Cosgrove, Justin Sheffield, Qingyun Duan, Lifeng Luo, R. Wayne Higgins, Rachel T. Pinker, J. Dan Tarpley, Dennis P. Lettenmaier, Curtis H. Marshall, Jared K. Entin, Ming Pan, Wei Shi, Victor Koren, Jesse Meng, Bruce H. Ramsay, Andrew A. Bailey

river basin CENTER

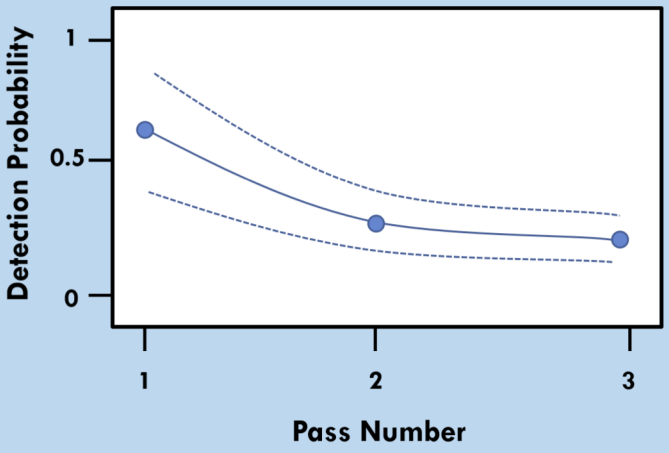
Multiple population viability analysis

1. Estimate extinction risks
2. Use ALL available data (all populations/years in one model)
3. Spatio-temporal covariates (remote sensing & GIS)
4. Forecasting and spatial extrapolation
5. Account for key sources of uncertainty
   - Demographic stochasticity
   - Observation error
   - Sampling error

MPVA: A hierarchical Bayesian model

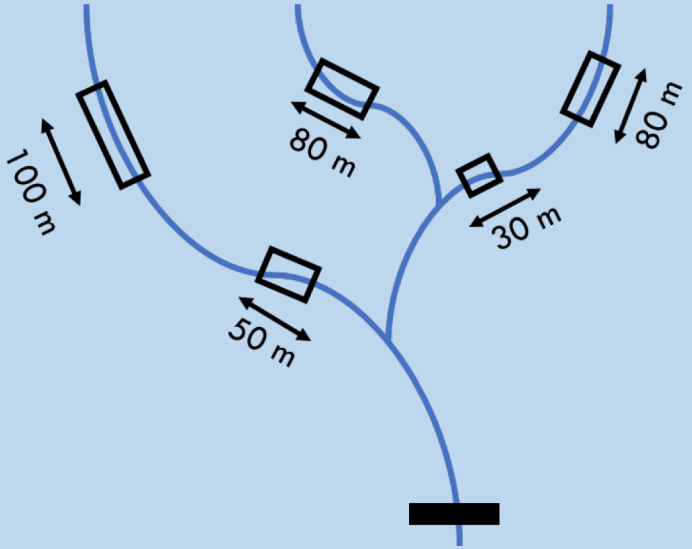
Observation Model

Site abundance = observed + unobserved animals



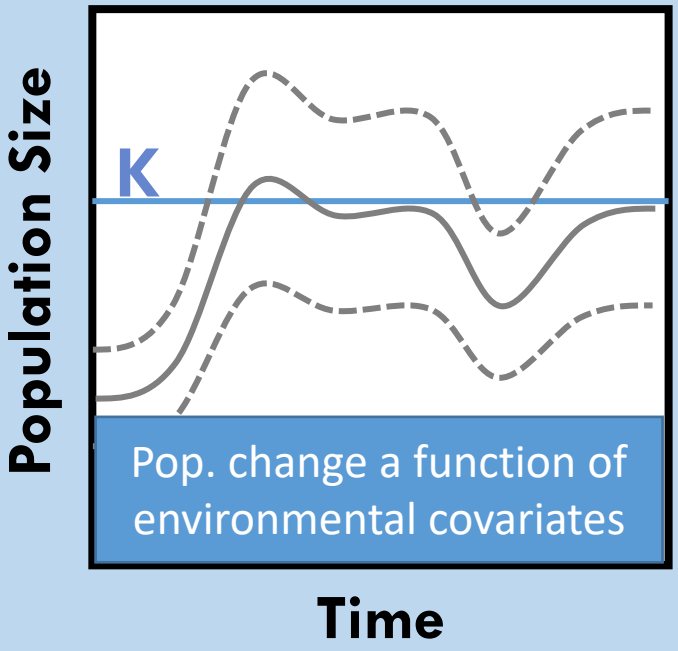
Sampling Model

Total population = sampled + unsampled habitat



Process Model

Population change = births - deaths



Lahontan Cutthroat Trout Population Simulator

Population:

Abel

Forecast year:

2020 2045 2115

2020 2030 2040 2050 2060 2070 2080 2090 2100 2110 2115

Future Conditions

Reset

Population extent (km):

7.32

Non-native trout:

- Use historic densities
- Set a constant density (slider below)

139 per km 2,000 per km

0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000

Stream habitat:

Temperature

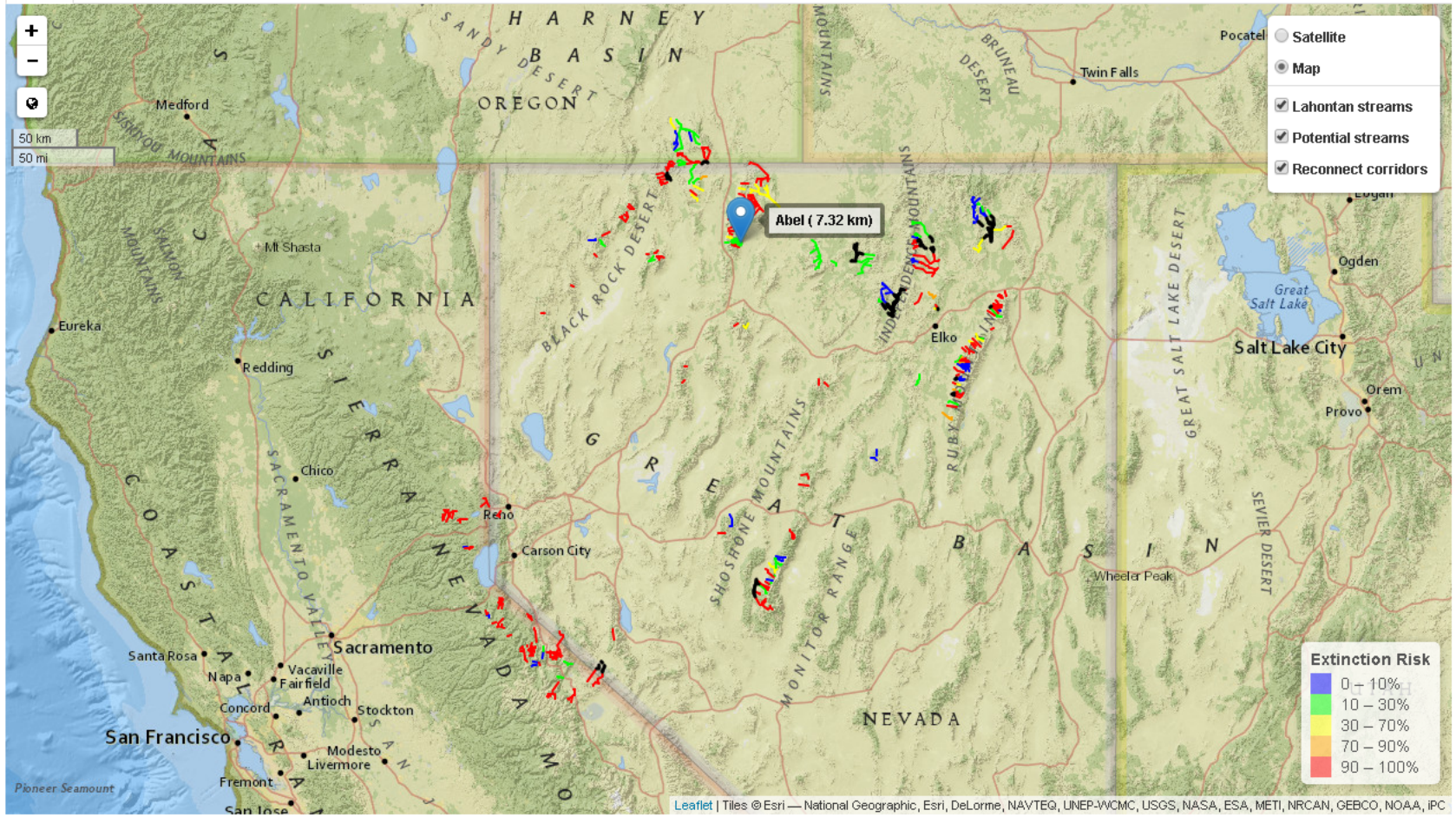
0 1

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

High flow

0 1

Map | Population | Habitat | Effects | Detection | Data | Help | About



Last Update: Tue Apr 25 18:24:54 2017

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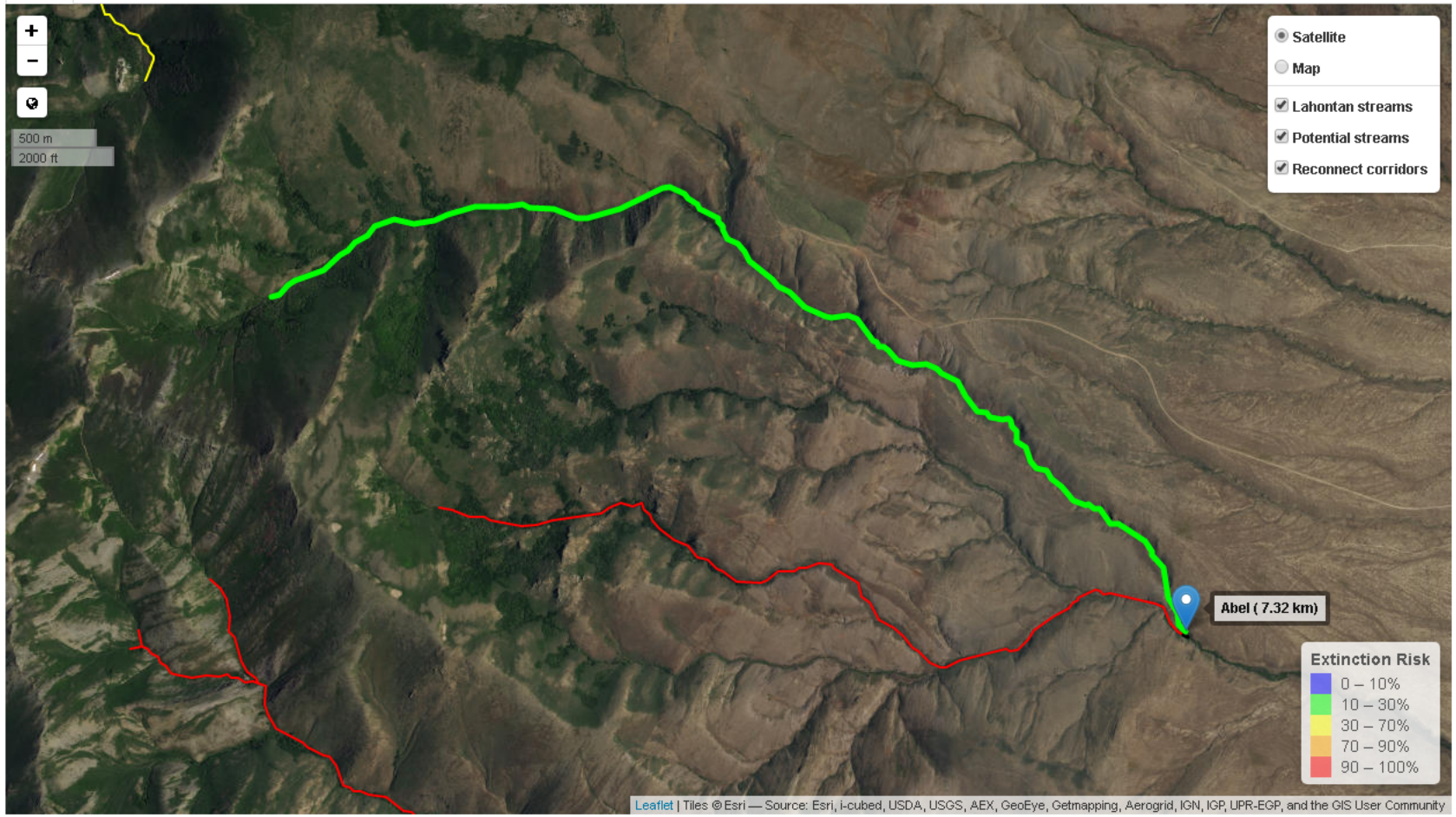

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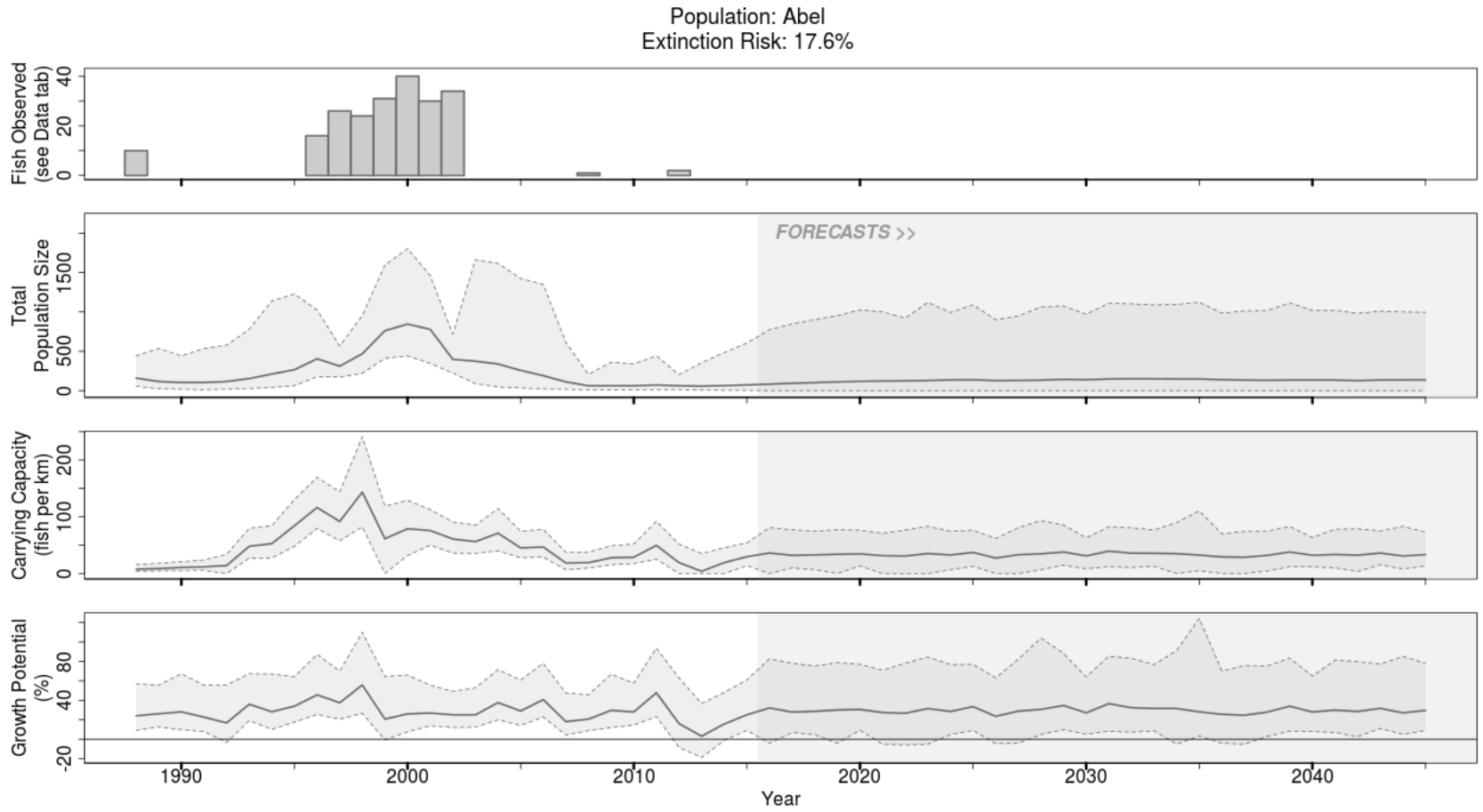

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Secure | https://trout.shinyapps.io/lahontan/

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High flow

0 1

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Population: Abel
Extinction Risk: 17.6%

FORECASTS >>

Non-native Density (fish per km) 0 400 800

Water Temp (C) 12.5 13.5

High Flow (m3/h) 1000 3000 5000

Riparian Vegetation (NDVI) 0.32 0.38 0.44

1990 2000 2010 2020 2030 2040

Year

NEVADA DEPARTMENT OF WILDLIFE

OREGON Fish & Wildlife

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

NorWeST Stream Temp

NLDAS

Landsat Program

Last Update: Tue Apr 25 18:24:54 2017

1:31 PM
5/17/2017

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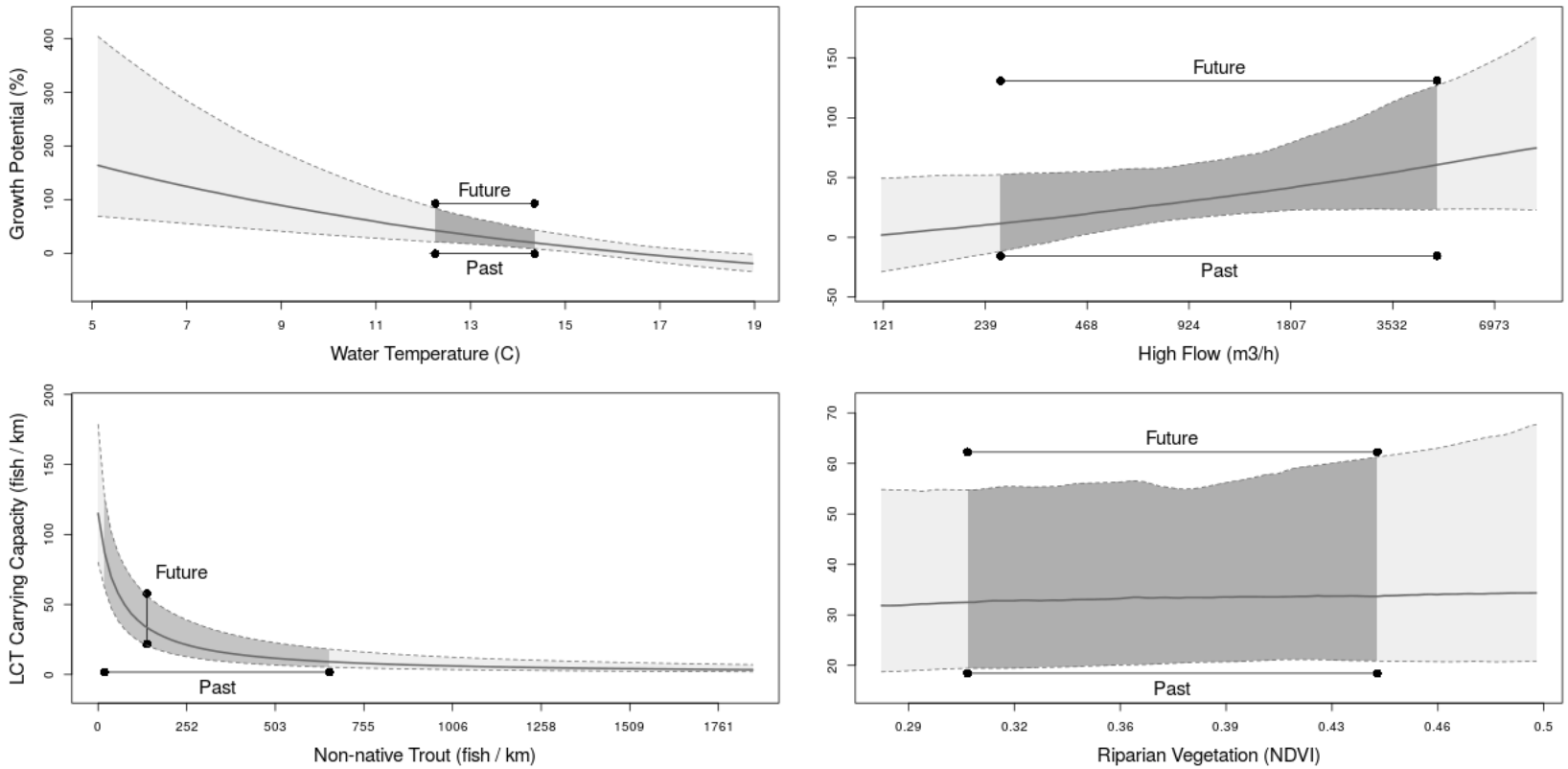

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Map | Population | Habitat | Effects | Detection | Data | Help | About

Year	Site	Length_m	Pass	Fish
1988	1	30	1	0
1988	2	30	1	0
1988	3	30	1	0
1988	4	30	1	0
1988	5	30	1	10
1996	1	25	1	0
1996	1	25	2	0
1996	1	25	3	0
1996	1	25	4	0
1996	2	25	1	0
1996	2	25	2	0
1996	2	25	3	0
1996	3	25	1	0
1996	3	25	2	0
1996	3	25	3	0
1996	4	25	1	3
1996	4	25	2	1
1996	4	25	3	0
1996	5	25	1	3
1996	5	25	2	0
1996	5	25	3	0
1996	6	25	1	3

Last Update: Tue Apr 25 18:24:54 2017

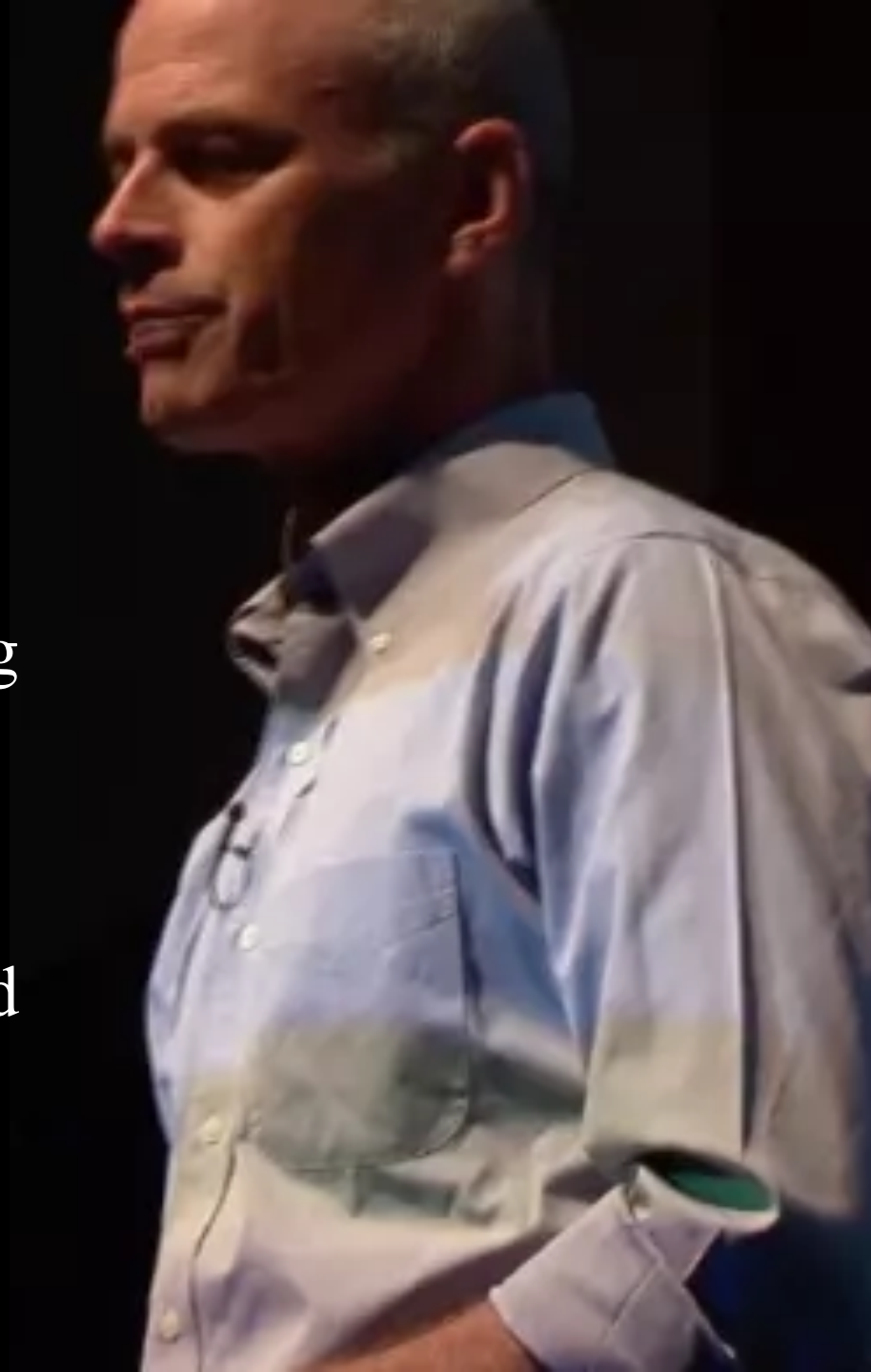

"I am thrilled with the outputs and their applicability to real time decision making"
"The results have exceeded my expectations"
--Lee Ann Carranza
U.S. Fish & Wildlife Service
TROUT UNLIMITED
FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR
NEVADA
DEPARTMENT OF WILDLIFE
OREGON
Fish & Wildlife
CALIFORNIA
DEPARTMENT OF FISH & WILDLIFE

"The prospect of using this to make better informed decisions about where to focus restoration and reintroduction efforts is truly game-changing."

"I can honestly say that in my more than 15 years now with Trout Unlimited that was the most exciting and potentially important presentation I've ever heard."

-- Chris Wood, CEO Trout Unlimited

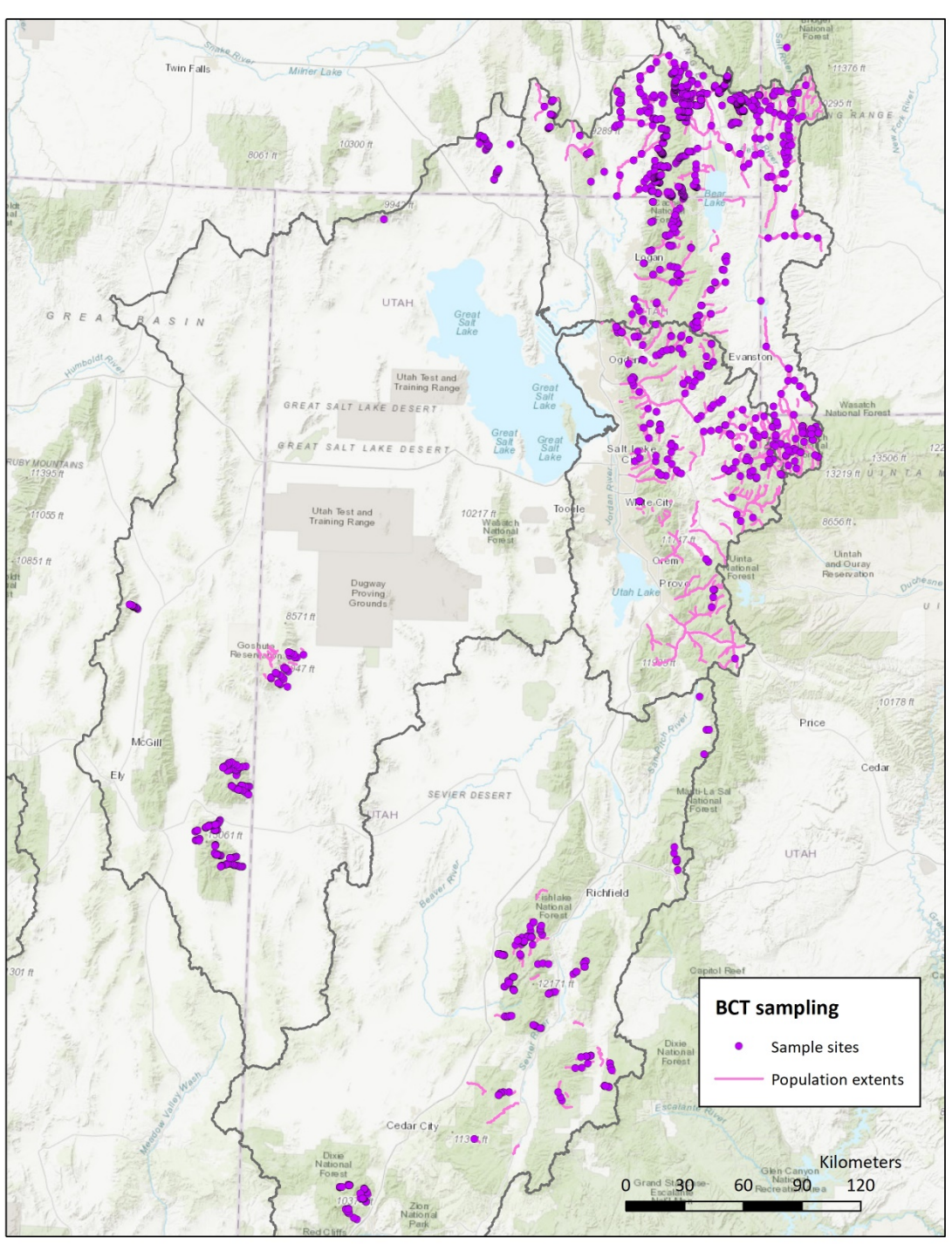
TROUT UNLIMITED



Bonneville Cutthroat Database

- 1980 – 2016
- 229 Populations (132 pops have data)
  - 207 Conservation Populations
  - 22 Other Populations

- 927 Sample Sites
- 1,763 Sampling Events
- 95,170 Individual Fish



Bonneville Cutthroat Trout Population Simulator (v0.1 beta) **PRELIMINARY RESULTS WITH KNOWN ERRORS**

Population:

BearWF

Forecast year:

2020 2045 2115

2020 2030 2040 2050 2060 2070 2080 2090 2100 2110 2115

Future Conditions

Reset

Change in population extent (km):

0

Non-native trout:

- ○ Use historic densities
- ◉ Set a constant density (slider below)

15 per km — 2,000 per km

0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000

Demographic stochasticity:

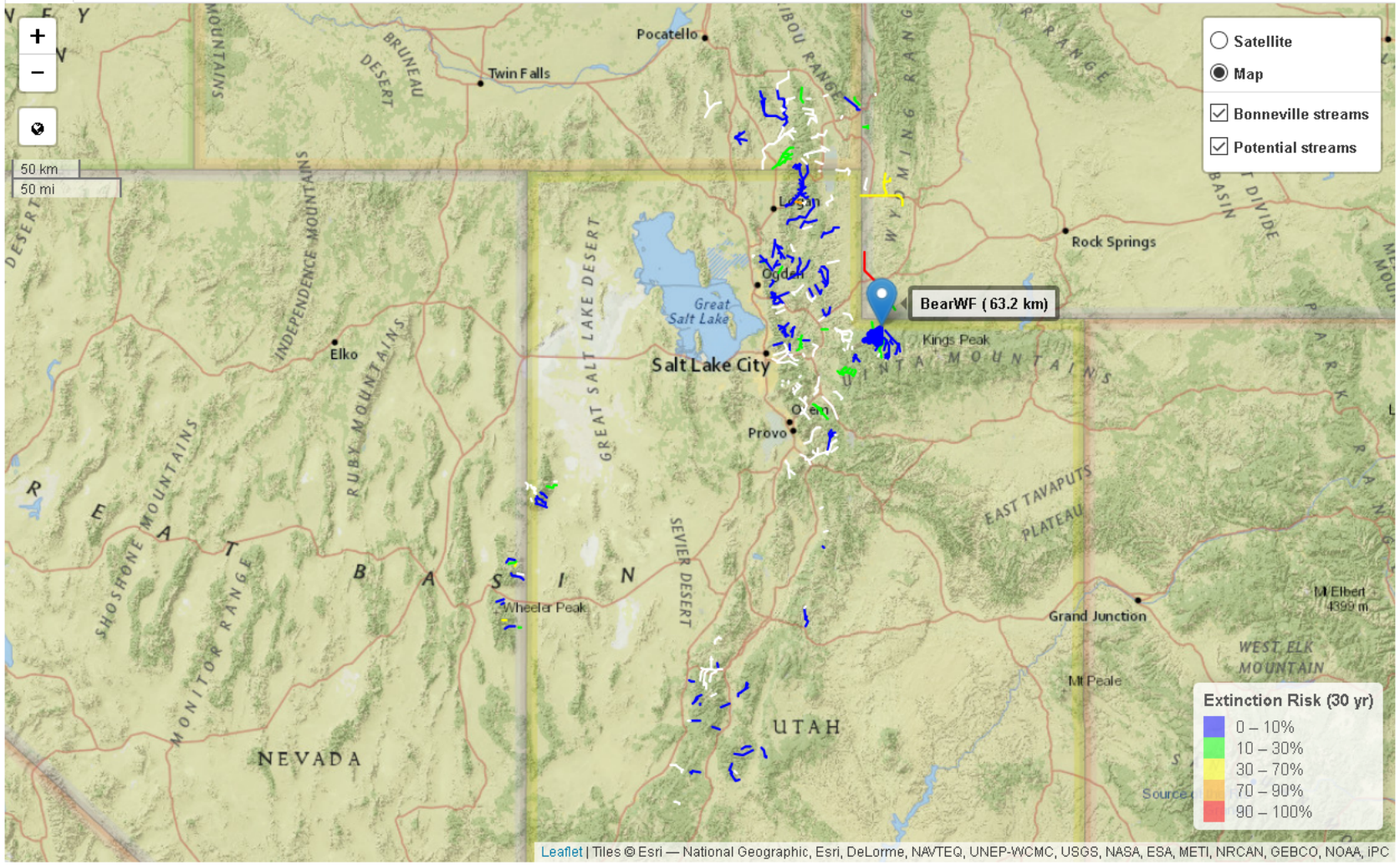
0.31 — 2

0.25 0.43 0.61 0.79 0.97 1.15 1.33 1.51 1.69 1.87 2

Stream Habitat:

Sliders define the range of historical values used for forecasting

Map | Population | Habitat | Effects | Detection | Data | Batch | Help | About



Last Update: Sun Nov 12 22:56:22 2017 (Version 0.1 beta)

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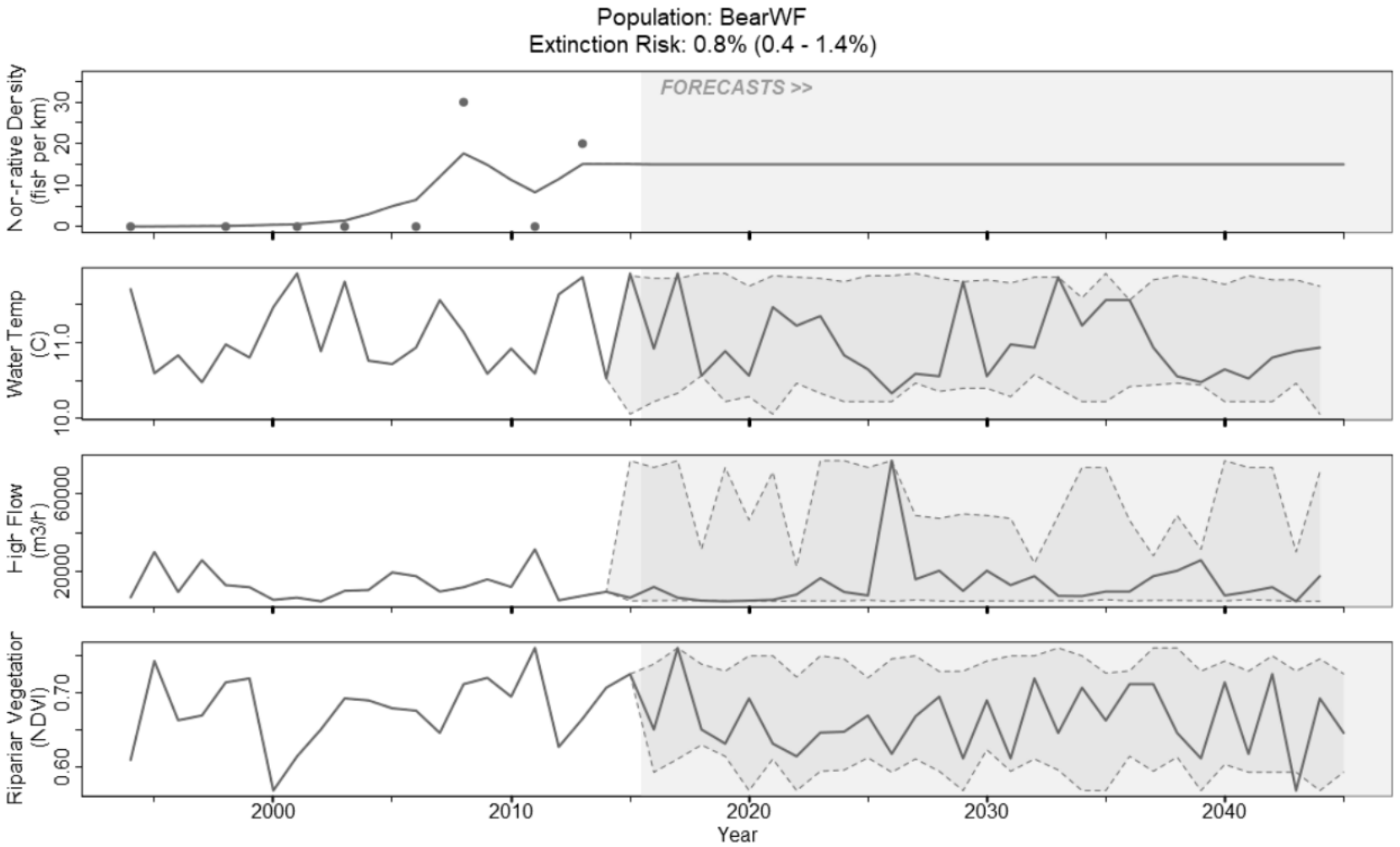

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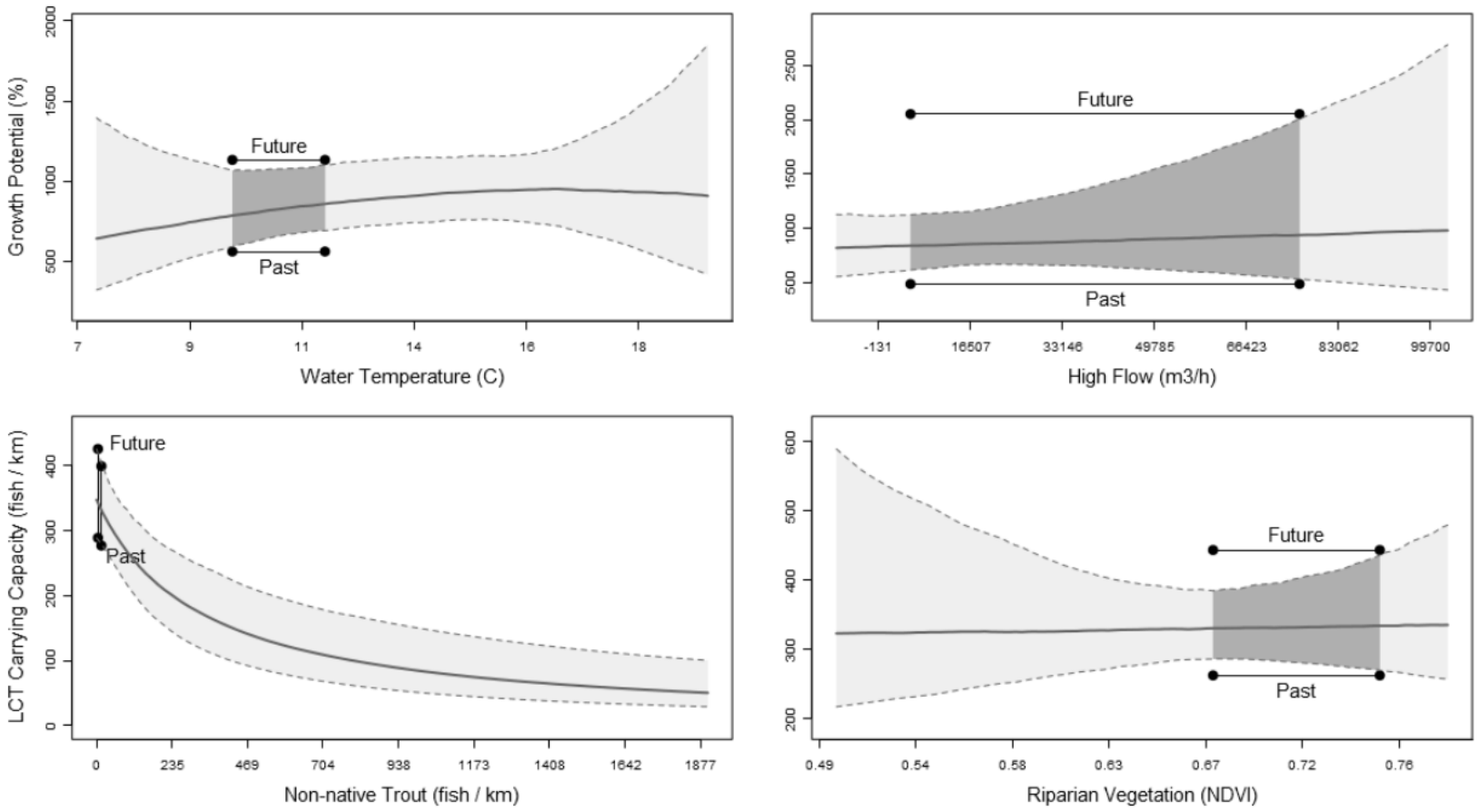
Population: BearWF
Extinction Risk: 0.8% (0.4 - 1.4%)



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Covariates for Bonnevilles

Field-based

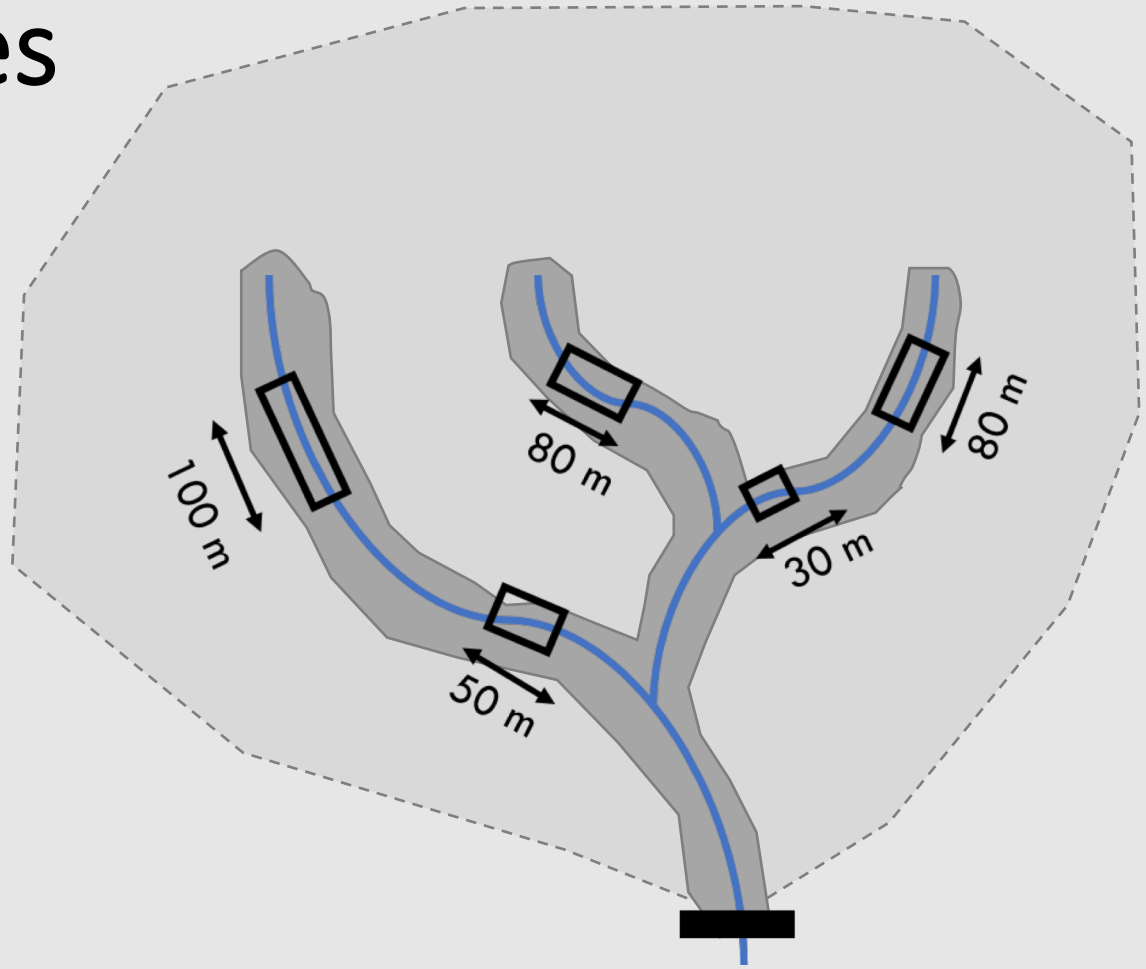
- Population-level habitat condition
- Detection covariates

Time static

- Road density
- Coverage of surficial geology (water chemistry; *e.g.* Olson et al.)

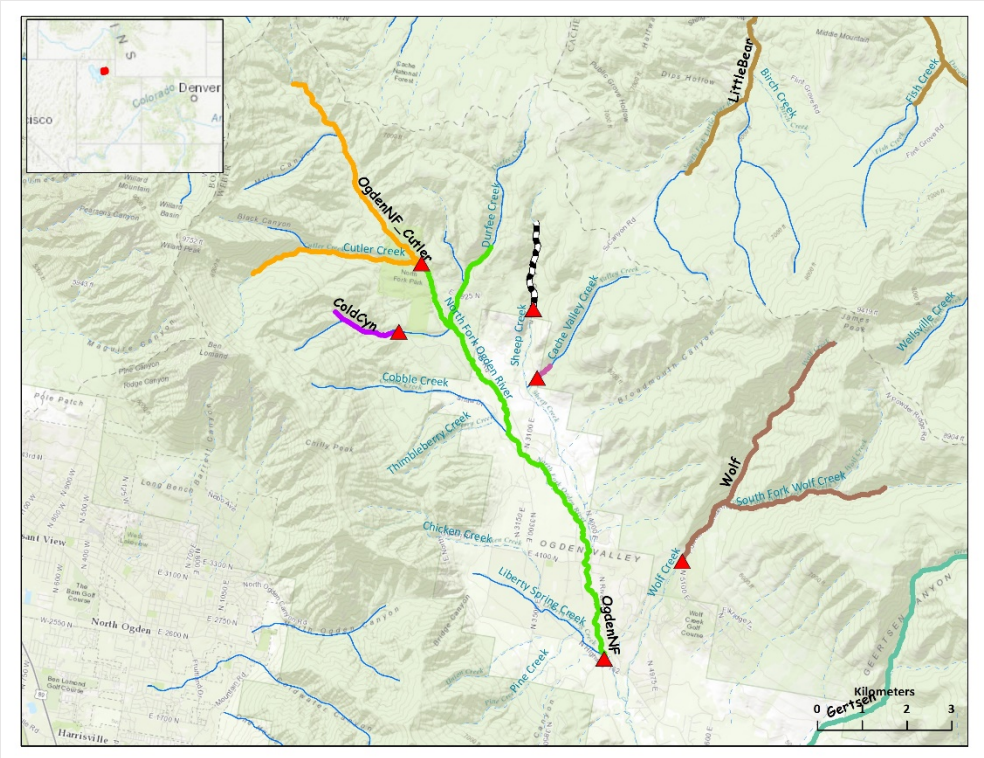
Annual measurements

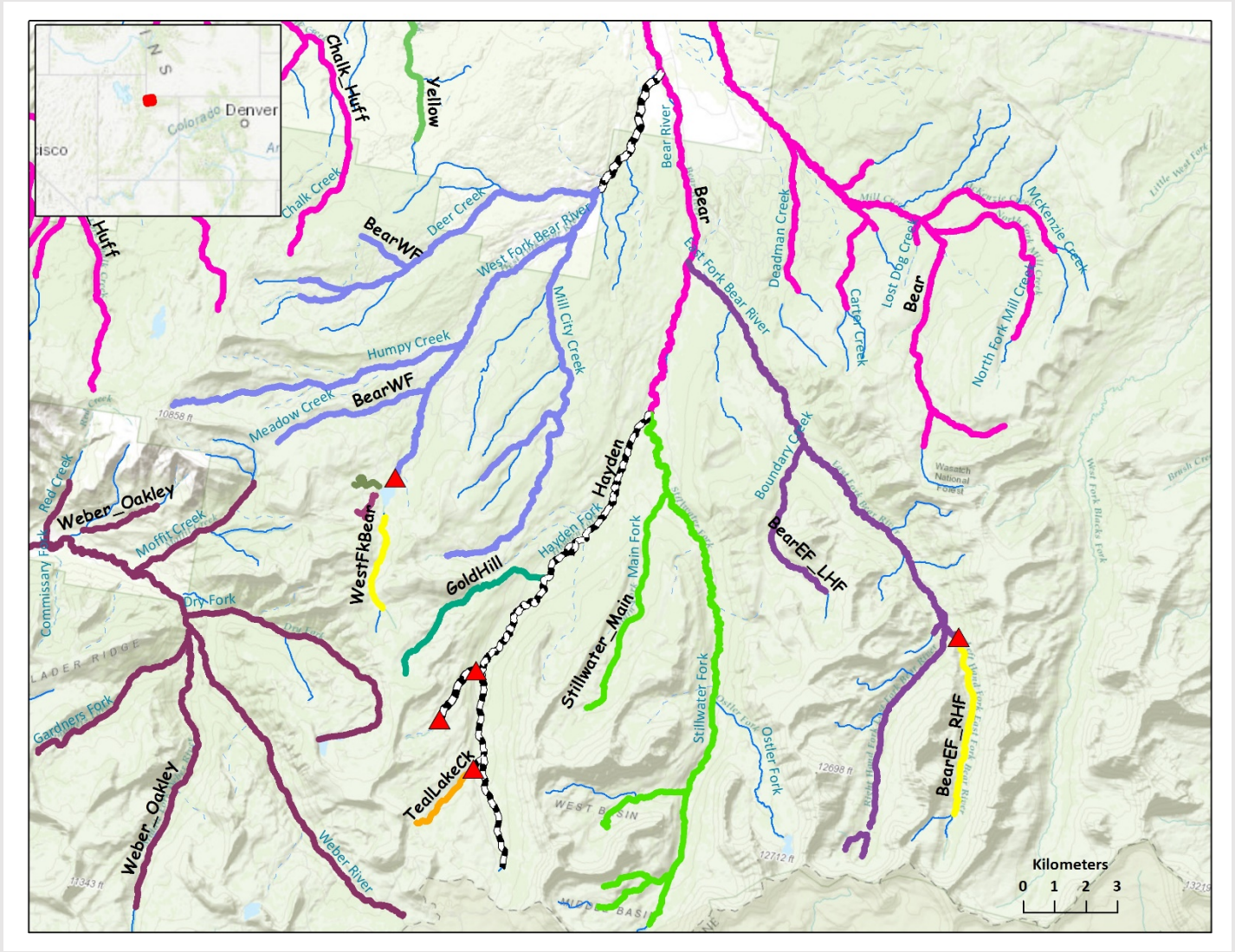
- NDVI
  - Separate effects by elevation threshold
  - Proportion above threshold (*i.e.* coverage of forest)
- Proportion below temperature threshold (*i.e.* thermal refugia)
- Night-time lights (yearly index of human impact)



Potential issues

- Non-isolated populations
- Adfluvial populations
- Reconnect scenarios
- Lakes as movement corridors





Collaborators

River Basin Center, University of Georgia

Seth Wenger, Doug Leasure

Trout Unlimited, Boise, ID

Helen Neville, Dan Dauwalter, Robin Bjork, Kurt Fessenmyer, Jean Barney

USGS Aquatic Sciences Lab, Corvallis, OR

Jason Dunham, Nate Chelgren

University of Nevada—Reno

Mary Peacock

Rocky Mountain Research Station

Charlie Luce, Abby Lute

University of Montana

Erin Landguth

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U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT
NATIONAL FISH AND WILDLIFE FOUNDATION NFWF
U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR
Seattle City Light

Lahontan Cutthroat Trout Population Simulator

trout.shinyapps.io/lahontan